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Original Research

Impact of clinical pharmacists in medication management within the diabetic foot multidisciplinary team

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Abstract

Background: Diabetic foot complications account for about 20% of diabetes-related hospital admissions worldwide and are a leading cause of non-traumatic lower limb amputations. In Saudi Arabia, approximately 3,970 diabetes-related amputations occur each year. Clinical pharmacists can enhance medication management and patient education for those with diabetic foot disease, although evidence of their impact is limited. The purpose of this study is to assess the effectiveness and role of a Clinical Pharmacist within a Multidisciplinary Diabetic Foot Team. **Method:** This retrospective, single-institution study involved two patient groups: those who visited the clinical pharmacist DM-Foot clinic (Group P1) and those who did not (Group P0). Primary outcomes included a composite measure of HbA1c, LDL reduction, no re-infection, and patient adherence. Secondary outcomes comprised LDL and HbA1c differences, re-infection, major/minor amputations, 30-day readmission rates, and mortality. **Results:** A total of 200 patients participated, with 100 in each group. The composite outcome was achieved by 100% of patients in Group P1 compared to 87% in Group P0 (P <0.001). Group P1 exhibited significant improvements in re-infection rates (34% vs 77%, p < 0.001), HbA1c reduction (75% vs 43%, p < 0.001), LDL reduction (78% vs 14%, p < 0.001), and medication adherence (93% vs 38%, p < 0.001). No significant differences were noted in mortality, readmission rates, or amputation rates between the groups. **Conclusion:** Clinical pharmacists significantly contribute to the diabetic foot multidisciplinary team, improving infection prevention and medication adherence.

Keywords: Clinical pharmacist, diabetic foot, medication management, multidisciplinary team

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INTRODUCTION

Diabetic foot complications, including foot ulcers, infections, peripheral artery disease, and neuropathy, are a severe subset of diabetes-related conditions. These complications are frequently difficult to manage and can lead to long-term disability, extended hospital stays, reduced quality of life, and, in many cases, lower limb amputations[1,2]. The clinical impact of diabetic foot disorders is considerable. Both HbA1c and LDL are essential for assessing diabetes control and complication risk[3]. Reducing HbA1c to below 7% significantly lowers the risk of microvascular complications, such as neuropathy and delayed wound healing, which can lead to diabetic foot ulcers[4]. Similarly, maintaining LDL-C levels under 100 mg/dL (or 70 mg/dL for high-risk patients) improves circulation and reduces atherosclerotic complications, facilitating better wound recovery[5].

Patients with foot ulcers have a higher risk of mortality, estimated to be 2.5 times greater than diabetic patients without foot complications[6]. Additionally, the recurrence rate of diabetic foot ulcers remains high, with reports indicating up to 40% of patients develop a new ulcer within one year of healing, and nearly 65% within five years[7]. Globally, diabetic foot complications account for about 20% of all diabetes-related hospital admissions and are a leading cause of non-traumatic lower limb amputations[8,9]. The burden extends beyond the individual, as healthcare systems must contend with the increased demand for surgical interventions, wound care supplies, long-term rehabilitation, and frequent re-hospitalizations.

In the Kingdom of Saudi Arabia, the number of diabetes-related lower limb amputations is estimated at 3,970 annually[10,11]. In response to this increasing need, the Saudi healthcare system has been adopting more multidisciplinary care models to improve patient outcomes and reduce the burden of complications related to diabetes. Within these multidisciplinary frameworks,

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clinical pharmacists have emerged as valuable healthcare providers[12]. Globally, numerous studies have shown that pharmacist-led interventions can significantly enhance multiple clinical parameters.

The expertise of clinical pharmacists in pharmacotherapy, patient education, chronic disease monitoring, and medication reconciliation is crucial for optimizing diabetes management. Clinical pharmacists play a role in ensuring the safe and effective use of medications, identifying and resolving drug-related problems, and enhancing adherence through personalized counseling and follow-up. These interventions can be particularly beneficial in patients with diabetic foot disease, who often require complex medication regimens for glycemic control, treating infections, and reducing cardiovascular risk[13-17].

The clinical pharmacist's scope within the DMFoot clinic included: conducting comprehensive medication review and optimization for diabetes, dyslipidemia, cardiovascular risk, and infection management; identifying and resolving drugrelated problems including dosing errors, drug–drug interactions, and adverse effects; adjusting therapies in collaboration with treating physicians based on guidelines; providing individualized patient counseling to enhance safe medication use and adherence; monitoring clinical and laboratory outcomes such as HbA1c, LDL, renal function, and response to therapy; and ensuring continuity of care during transitions from inpatient discharge to outpatient followup to prevent reinfection, complications, or medication errors[12,13,15].

In a study evaluating the role of pharmacists within a multidisciplinary diabetes team, which included a diabetologist-geriatrician, nurse, and dietitian, significant contributions were identified in managing older patients with diabetes. Over three years, pharmacists made 276 interventions for drug-related problems across 138 patients, addressing issues such as underutilization of therapies, potential adverse effects, and nonadherence. Their efforts included modifying prescriptions, managing risks associated with benzodiazepines, and preventing hypoglycemia. The findings underscore the crucial role of pharmacists in optimizing pharmacotherapy outcomes, highlighting their impact in reducing errors, improving adherence, and addressing the complex medication needs of older adults in diabetes care[18].

Many studies examine clinical pharmacists' provision of direct patient care to patients with diabetes in the outpatient setting, and this practice has been shown to improve patient outcomes[19,20]. Despite this, there remains a lack of literature specifically addressing their impact on diabetic foot disease. This study aims to address that gap by evaluating the outcomes of a pharmacist-led diabetic foot clinic within a multidisciplinary team at a tertiary care center. Our objective is to assess the role of clinical pharmacists in diabetic foot clinics in improving glycemic control and lipid profiles, reducing lower limb amputation rates, increasing medication adherence, and decreasing 30-day hospital readmissions and reinfections.

METHODS

Study Design

A single-center, retrospective cohort study involved adult patients with diabetic foot infection admitted to the Diabetes Mellitus Foot Center (DM-Foot Center) and who underwent an initial examination by the vascular surgeon and the wound care team at a tertiary hospital in Saudi Arabia. Following their discharge from the hospital, all patients were seen by a clinical pharmacist at the DM-Foot clinic twice a week and monitored until all acute issues were resolved. Eligible patients were divided into two groups based on their visits to the DM-Foot clinic: those who visited the clinic (Group P1) and those who did not (Group P0). The role of a clinical pharmacist includes reviewing and managing the patient's medication regimen, optimizing medications and dosages, detecting drug interactions, and monitoring possible side effects. The assigned clinical pharmacist cares for a maximum of ten patients per week in the clinic, in addition to conducting 4-6 follow-up visits for each patient if needed.

Study Participants

All patients who visited the DM-Foot clinic were included in the study, while patients under 18 years old were excluded from it.

Study outcomes

The primary outcome was to investigate the composite outcome of patients in both groups. This outcome was defined by whether the patients experienced one or more of these outcomes: HbA1c reduction, LDL reduction, not re-infected, and patient adherence. The secondary outcomes included the difference in LDL reduction, HbA1C reduction, patient adherence (by direct questioning or MMAS-8 questionnaire), re-infection, major amputation, minor amputation, 30-day readmission rate, and mortality.

Outcomes definitions

Reduction in HbA1C: A patient is considered to have a reduction in HbA1C if the value at the follow-up visit is lower by 0.3% or more compared to the baseline. This threshold was selected because reductions of 0.3–0.5% have been identified in the literature as minimally clinically important changes that exceed analytic and biological variability and reflect true shortterm glycemic improvement, particularly in outpatient interventional care models[21].

Reduction in LDL: A patient is considered to have a reduction in LDL if the value at the follow-up visit is reduced by 30% or more compared to the baseline(22). This threshold aligns with ACC/AHA cholesterolmanagement guidelines, which define ≥30% reduction as the expected therapeutic response to

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moderateintensity statin therapy. This cutoff is also commonly used in lipidlowering trials and is associated with meaningful ASCVD risk reduction[5,22,23].

Medication adherence: This is assessed through direct inquiry, which involves openly asking patients about their medication usage[24].

MMAS-8 score: Adherence levels are measured using a standard scale consisting of eight items. A score of 6 or above indicates patient adherence[25].

Major amputations: Surgical procedures performed above the ankle[26].

Minor amputations: Surgical procedures performed at the level of the ankle and below[26].

Data Collection

A random sample of patients who were following up in the DM foot clinic was extracted from the hospital database from July 2024 to December 2024. Demographic information, clinical outcomes, test results, adherence ratings, and 30-day readmission rates were obtained by reviewing both electronic and paper records.

Statistical analysis

Continuous variables were presented as mean and standard deviation (SD), while categorical variables were presented as numbers and percentages. The Mann-Whitney U test was used for non-normally distributed continuous variables to study differences in means. For categorical variables, the Chi-square test was used to study differences in proportions. The Wilson signed rank test is used to measure the difference between the values from the baseline and the follow-up visits that are not normally distributed for the dependent group. We considered a P value of < 0.05 as an indicator of statistical significance. Because this study had a retrospective design and a modest sample size, multivariable adjustment for potential confounders such as baseline HbA1c, LDL-C, comorbidities, or ulcer severity was not performed. Only bivariate analyses (Chisquare and MannWhitney U) were conducted; therefore, residual confounding may be present. Statistical analyses were performed using IBM Statistical Package for Social Sciences (SPSS) software (version 27).

RESULTS

Demographic and clinical characteristics

A total of 200 patients participated in the study. One hundred patients were seen by the clinical pharmacist in the diabetes mellitus (DM) foot clinic (P1), while the other hundred patients had never consulted the clinical pharmacist in the DM foot clinic (P0). The mean age of patients in the P0 group was 63 ± 12.3 years, and in the P1 group, it was 64 ± 12 years. In terms of gender distribution, 71% of participants in both groups were male, while 29% were female. Additionally, the prevalence of hypertension and dyslipidemia was higher in the P1 group compared to the control group. No significant differences were observed in other basic characteristics between the two groups (Table 1).

Primary Outcomes

The composite outcome represents patients who had either reduced HbA1c, reduced LDL levels, not reinfected, or medication adherence, which was achieved by 100 percent of patients in the P1 group, compared to 87 percent in the other group (P <0.001). Visit to the DM foot clinic led to more than a 70 percent reduction in both HbA1c and LDL levels (P < 0.001). The reinfection within 30 days was more prevalent in the control group (77 versus 34; P <0.001). Additionally, the medication adherence measured via a direct open question to the patients was 93 percent in the P1 group versus 38 percent in the control group (P <0.001). However, less than 40 percent of the patients achieved less than 6 points in the MMAS-8 score, and there was no significant difference in the MMAS-8 score between the two groups (P=0.236) (Table 2).

The reduction in HbA1C and LDL

The difference between the baseline and the follow-up visits in both HbA1C and LDL was statistically significant in the intervention group. Instead, the difference in both HbA1C and LDL was not statistically significant in the control group (Table 3). Furthermore, comparing the number of patients who confirm a reduction in HbA1c and LDL. HbA1c reduction was achieved in 43% of patients in the P0 group and 74% in the P1 group, showing a significant improvement in the reduction rate by 74% in the P1 group compared to the P0 group (p <0.001) (Figure 1). Similarly, the LDL reduction in the P0 group was found in only 14% of the patients, while 78% did show LDL reduction in the P1 group; this reduction significantly increased in the P1 group relative to the P0 group (p <0.001) (Figure 1).

Adherence to medication regimens

Patient adherence, as measured by direct questioning, significantly increased from 38% in the control group to 93%

Table 1. Demographics and basic characteristics

Demographics and basic characteristics	P1 (100 patients)	P0 (100 patients)
Age by year; Mean (SD)	63 (12.3)	64 (12)
Male n(%)	71	71
HTN n(%)	55	73
DLP n(%)	17	48
CKD n(%)	13	29
ESRD n(%)	8	10

Abbreviation: DM: Diabetes mellitus, HTN: Hypertension, DLP: Dyslipidemia, CKD: Chronic kidney disease, ESRD: End-stage renal disease.

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Table 2. Patient outcomes in control and intervention groups.

Patient outcomes	P1 (100 patients)	P0 (100 patients)	p-value
Composite outcome %	100	87	<0.001
HbA1c Reduction%	75	43	<0.001
LDL Reduction%	78	14	<0.001
Patient adherence%	93	38	<0.001
MMAS-8 (scored 6 or above) %	39	31	0.236
Re-infection%	34	77	<0.001
Readmission within 30 days%	8	7	0.789
Major Amputation%	12	18	0.236
Minor amputation%	34	32	0.764
Mortality%	5	9	0.269

Table 3. Difference between baseline and follow-up intervals

Objective		Baseline	Follow-up visit	p-value
HbA1c mean (SD)	P0	9.54 (0.64)	9.49 (0.71)	0.076
	P1	9.59 (0.59)	8.80 (0.72)	<0.001
LDL mean (SD)	P0	92.82 (31.05)	89.91 (29.09)	0.21
	P1	98.43 (24.89)	70.21 (18.71)	<0.001

among patients who attended the clinical pharmacist-led diabetic foot clinic (P1 group) ($p < 0.001$) (Figure 3). In contrast, the MMAS-8 score modestly improved from 31% to 39% in the P1 group compared to the control group; however, this difference was not statistically significant ($p = 0.236$).

Re-infection and amputation

The re-infection rate was significantly lower in the P0 group compared to the P1 group (77% vs 34%; $p < 0.001$) (Figure 2). However, major amputation rates were 18% in the control group versus 12% in the intervention group, while minor amputation rates were 32% and 34%, respectively. These differences in amputation rates were not statistically significant between the groups (Figure 4).

30-day readmission and Mortality rate

The findings show that 30-day readmission rates were relatively low, occurring in 7% of patients in the control group and 8% of those who attended the clinical pharmacist-led diabetic foot clinic (see Figure 2). Additionally, mortality was 9% in the control group compared to 5% in the P1 group (Figure 5). However, the differences in both outcomes were not statistically significant.

DISCUSSION

A total of 200 patients participated in the study. Of these, one hundred patients were seen by a clinical pharmacist at the diabetes mellitus (DM) foot clinic. All patients who consulted the clinical pharmacist achieved the composite outcome, which included decreased glycated hemoglobin (HbA1c) or low-density lipoprotein cholesterol (LDL) levels, not reinfected within 30 days, or improved patient adherence. In this study,

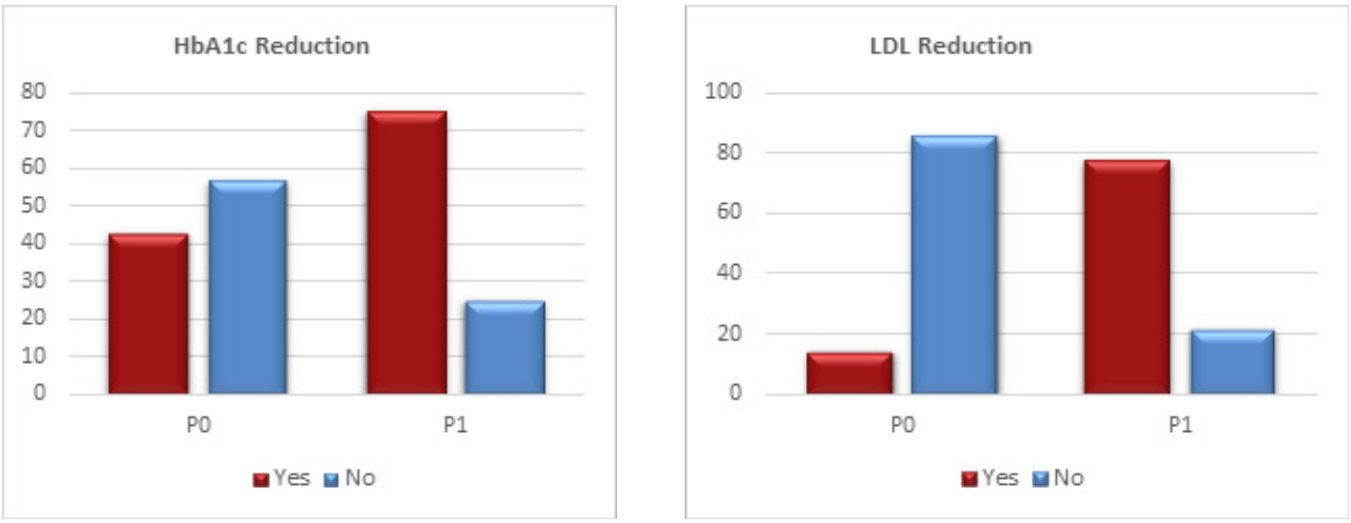

Figure 1. The following figure exhibits the reduction in HbA1C and LDL. Both HbA1C and LDL reduction rates were significantly reduced after the role of the clinical pharmacist.

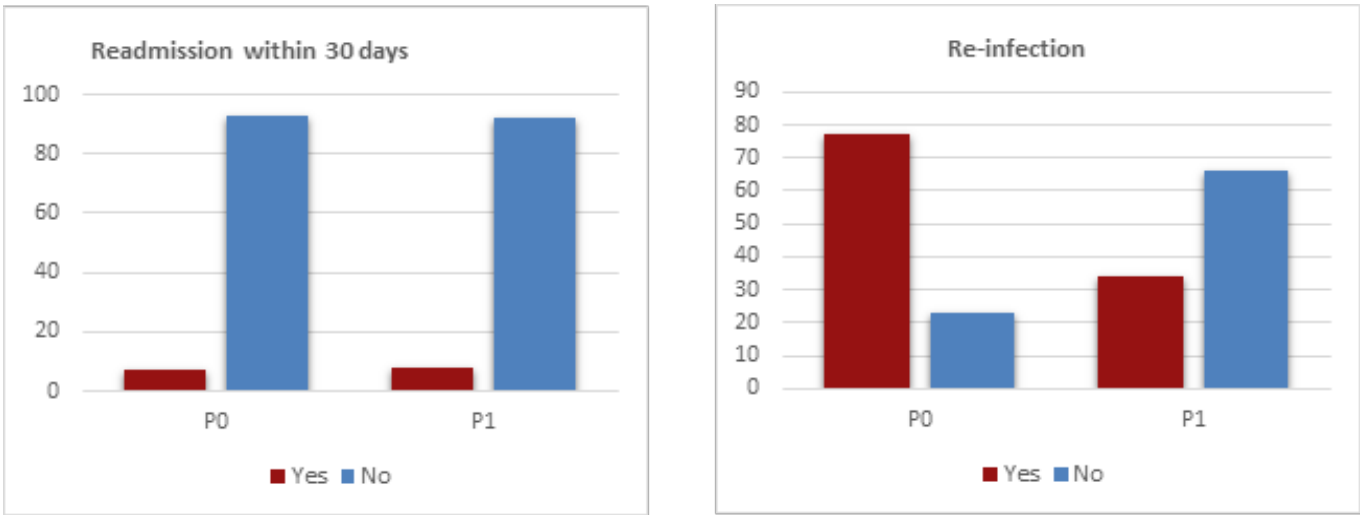

Figure 2. Represents the readmission within 30 days and the re-infection rate. The re-infection rate was significantly reduced after the role of a clinical pharmacist

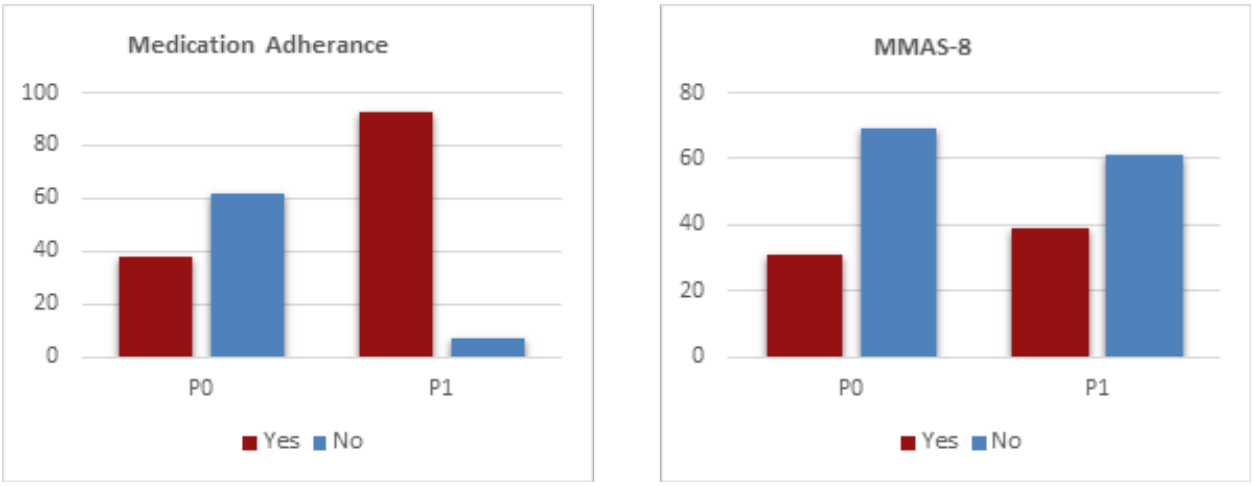

Figure 3. This figure represents the medication adherence and MMAS-8.

we attempted to evaluate the role of clinical pharmacists in diabetic foot clinics, specifically focusing on improving glycemic control and lipid profiles.

We found that reducing both LDL and HbA1c significantly. Our results are consistent with a retrospective cohort study that involved type 2 diabetes patients who consulted a clinical pharmacist for at least one visit[27]. The study by Alqifari et al.[27], evaluated the impact of pharmacists on diabetic patients. They observed significant improvements in controlling diabetes by achieving a significant lowering of HbA1c, frequency of hypoglycemia, and transitioning patients to newer antihyperglycemic agents after nine months of care by clinical pharmacists compared to usual care. However, the Ourth et al.[28] study was designed to investigate the effectiveness and safety of hyperglycemia management in diabetic patients provided by a clinical pharmacist. They found that while there was no difference at three months, patients in the pharmacist-managed group were 15% and 37% more likely to reach an HbA1c value of <8% at 6 and 12 months, respectively[28]. Our findings are consistent with previous literature demonstrating that clinical pharmacist involvement significantly improves lipid management outcomes. The high rates of LDL goal attainment reported by Cording et al., Geber et al., and Bozovich et al. highlight the effectiveness of pharmacist-led interventions in optimizing therapy and ensuring adherence to treatment guidelines[29-31].

Cording et al.[29], showed that 77% of patients managed by pharmacists reached LDL goals. Similarly, Geber et al.[30], found that 85% of patients in a pharmacist-managed clinic achieved an LDL level of less than 105 mg/dL. Bozovich et al.[31], reported that 69% of patients reached their LDL goals in pharmacist-run clinics. In contrast, Till et al.[32], reported a decrease in LDL by more than 50% and reductions in total cholesterol levels in the group managed by clinical pharmacists. Our study confirms the positive impact of clinical pharmacist involvement. These outcomes can be explained by the unique contributions of clinical pharmacists, including individualized patient education, medication adjustments, and support for adherence strategies.

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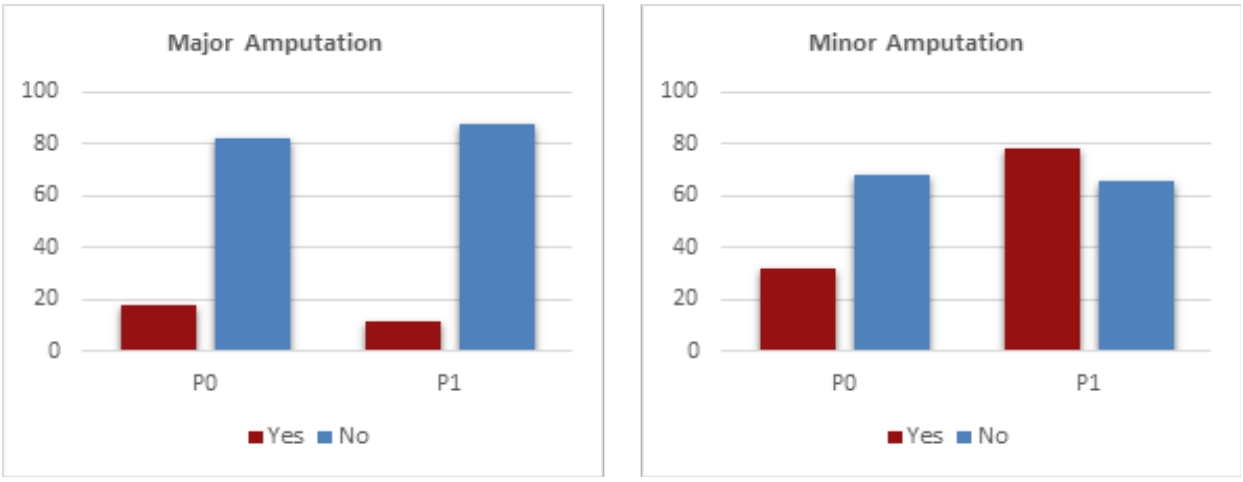

Figure 4. The figure shows the major and minor amputation rates in both groups.

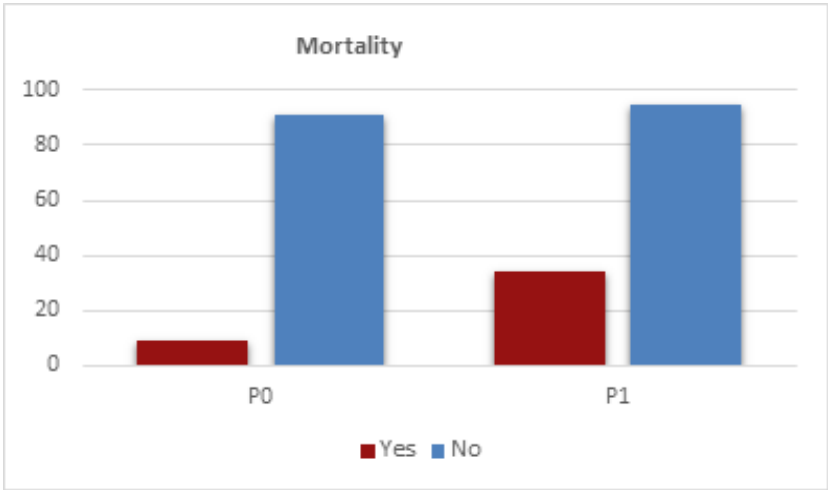

Figure 5. This figure represents the mortality.

In our study, patient adherence significantly improved when assessed through direct questioning, rising from 38% in the control group to 93% in the clinical pharmacist-led clinic group ($p < 0.001$). This highlights the effectiveness of pharmacist interventions through education, counseling, and regular follow-up. Interestingly, when using the MMAS-8 scale, adherence showed only a modest increase from 31% to 39%, which was not statistically significant. This discrepancy may be attributed to the subjective nature and limited sensitivity of self-reported scales compared to direct assessment. It is also possible that patients demonstrated better adherence behaviors during follow-up visits when questioned directly, reflecting an immediate accountability effect. Similar findings have been reported in Saudi Arabia, where a pilot program in Riyadh suggested that integrating clinical pharmacists into diabetes care improved medication adherence[17]. Additionally, Casper et al.[33], also reported improved adherence in patients managed by pharmacists. These results support that the involvement of clinical pharmacists plays a role in identifying and addressing significant adverse drug events, ultimately leading to improved medication adherence across different clinical settings[34]. The discrepancy between adherence measured via direct questioning and the MMAS8 tool mirrors findings in the literature. Direct selfreported adherence is known to overestimate true adherence because patients may be influenced by recall limitations and social desirability tendencies when responding to healthcare providers. In contrast, the MMAS8 evaluates multiple domains of intentional and unintentional non-adherence—including forgetfulness, routine difficulty, and stopping medication when symptomatic—which enables it to detect behaviors that patients may not disclose during general questioning[15,24,25].

In this study, the re-infection rate was significantly reduced in the pharmacist-led group compared with the control group (34% vs. 77%; $p < 0.001$), indicating a substantial impact of

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pharmacist intervention on infection control. While rates of major amputation and minor amputation did not differ significantly, the trend toward fewer major amputations in the intervention group suggests a potential clinical benefit that may become more evident with larger cohorts or longer follow-up. To date, no published studies have systematically evaluated the effect of clinical pharmacists on outcomes in diabetic foot patients.

This study has several limitations, including a relatively small sample size and recruitment from a single outpatient clinic, which may limit the generalizability of the findings. Because this was a retrospective study with a modest sample size, multivariable regression could not be conducted to adjust for baseline differences such as comorbidities, HbA1c, LDL-C, or ulcer severity. This limitation introduces the possibility of residual confounding and should be considered when interpreting outcome comparisons. Future studies with larger cohorts should employ adjusted models such as logistic regression or Cox proportional hazards to isolate the independent effects of pharmacist-led care. Nevertheless, it provides an important and novel contribution to the literature, as we believe it is the first study to specifically evaluate the clinical role and impact of a pharmacist-led care model in patients with diabetic foot complications and long-term clinical outcomes.

CONCLUSION

In conclusion, this study demonstrates that integration of clinical pharmacists into a multidisciplinary diabetic foot clinic can significantly improve patient outcomes, particularly in adherence and infection control. Future research with larger sample sizes is needed to evaluate the impact of clinical pharmacists within the outpatient multidisciplinary care team on long-term management of diabetic foot complications.

AUTHOR CONTRIBUTIONS

All authors critically revised the manuscript, agreed to be fully accountable for ensuring the integrity and accuracy of the work, and read and approved the final manuscript.

CONFLICTS OF INTEREST

No author has a conflict of interest in this study.

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